

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

**EP 0 966 003 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:

22.12.1999 Bulletin 1999/51

(51) Int. Cl.<sup>6</sup>: **H01B 3/44**, C08K 5/13,

H01B 7/28

(21) Application number: 99302852.1

(22) Date of filing: 13.04.1999

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: 16.06.1998 US 98478

(71) Applicant:

**UNION CARBIDE CHEMICALS & PLASTICS  
TECHNOLOGY CORPORATION**

Danbury, Connecticut 06817-0001 (US)

(72) Inventors:

- Caronia, Paul Joseph  
Annandale, New Jersey 08801 (US)
- Pang, Kawai Peter  
Neshanic Station, New Jersey 08853 (US)
- Keogh, Michael John  
Bridgewater, New Jersey 08807 (US)

(74) Representative:

Hayes, Adrian Chetwynd et al  
Boulton Wade Tennant,  
27 Fumival Street  
London EC4A 1PQ (GB)

(54) **Tree resistant cable**

(57) A composition comprising:

- (i) polyethylene, and, based on 100 parts by weight of component (i),
- (ii) about 0.3 to about 0.6 part by weight of 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis(2-t-butyl-5-methylphenol); 2,2'-thiobis(6-t-butyl-4-methylphenol); or a mixture of said compounds; and
- (iii) about 0.4 to about 1 part by weight of a polyethylene glycol having a molecular weight in the range of about 1000 to about 100,000.

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**Description****Technical Field**

- 5 [0001] This invention relates to electric power cable insulated with a polyethylene composition having an improved resistance to water trees.

**Background Information**

- 10 [0002] A typical electric power cable generally comprises one or more conductors in a cable core that is surrounded by several layers of polymeric material including a first semiconducting shield layer, an insulating layer, a second semiconducting shield layer, a metallic tape or wire shield, and a jacket.

- [0003] These insulated cables are known to suffer from shortened life when installed in an environment where the insulation is exposed to water, e.g., underground or locations of high humidity. The shortened life has been attributed to the formation of water trees, which occur when an organic polymeric material is subjected to an electrical field over a long period of time in the presence of water in liquid or vapor form. The formation of water trees is believed to be caused by a complex interaction of the AC electrical field, moisture, time, and the presence of ions. The net result is a reduction in the dielectric strength of the insulation.

- [0004] Many solutions have been proposed for increasing the resistance of organic insulating materials to degradation by water treeing. One solution involves the addition of polyethylene glycol, as a water tree growth inhibitor, to a low density polyethylene such as described in United States Patent 4,305,849. An improvement in electrical performance was provided by United States Patent 4,440,671. The combined teachings of these patents, however, left room for improvements in processability, e.g., scorch resistance and sweat-out.

**Disclosure of the Invention**

- [0005] An object of this invention, therefore, is to provide a polyethylene composition, which demonstrates exemplary processability in its conversion to a cable insulation in terms of scorch resistance and sweat-out, and provides commercially acceptable water tree resistance and heat aging. Other objects and advantages will become apparent hereinafter.

- 30 [0006] According to the invention, a composition has been discovered which meets the above object.

- [0007] The composition comprises

- (i) polyethylene, and, based on 100 parts by weight of component (i),  
 (ii) about 0.3 to about 0.6 part by weight of 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis(2-t-butyl-5-methylphenol); 2,2'-thiobis(6-t-butyl-4-methylphenol); or a mixture of said compounds; and  
 35 (iii) about 0.4 to about 1 part by weight of a polyethylene glycol having a molecular weight in the range of about 1000 to about 100,000.

**Description of the Preferred Embodiment(s)**

- 40 [0008] Polyethylene, as that term is used herein, is a homopolymer of ethylene or a copolymer of ethylene and a minor proportion of one or more alpha-olefins having 3 to 12 carbon atoms, and preferably 4 to 8 carbon atoms, and, optionally, a diene, or a mixture of such homopolymers and copolymers. The mixture can be a mechanical blend or an in situ blend. Examples of the alpha-olefins are propylene, 1-butene, 1-hexene, 4-methyl-1-pentene, and 1-octene.

- 45 [0009] The polyethylene can be homogeneous or heterogeneous. The homogeneous polyethylenes usually have a polydispersity (Mw/Mn) in the range of about 1.5 to about 3.5 and an essentially uniform comonomer distribution, and are characterized by single and relatively low DSC melting points. The heterogeneous polyethylenes, on the other hand, have a polydispersity (Mw/Mn) greater than 3.5 and do not have a uniform comonomer distribution. Mw is defined as weight average molecular weight and Mn is defined as number average molecular weight. The polyethylenes can have a density in the range of 0.860 to 0.950 gram per cubic centimeter, and preferably have a density in the range of 0.870 to about 0.930 gram per cubic centimeter. They also can have a melt index in the range of about 0.1 to about 50 grams per 10 minutes.

- [0010] The polyethylenes can be produced by low or high pressure processes. They are preferably produced in the gas phase, but they can also be produced in the liquid phase in solutions or slurries by conventional techniques. Low pressure processes are typically run at pressures below 1000 psi whereas high pressure processes are typically run at pressures above 15,000 psi.

- 55 [0011] Typical catalyst systems, which can be used to prepare these polyethylenes, are magnesium/titanium based catalyst systems, which can be exemplified by the catalyst system described in United States patent 4,302,565 (heter-

ogeneous polyethylenes); vanadium based catalyst systems such as those described in United States patents 4,508,842 (heterogeneous polyethylenes) and 5,332,793; 5,342,907; and 5,410,003 (homogeneous polyethylenes); a chromium based catalyst system such as that described in United States patent 4,101,445; a metallocene catalyst system such as that described in United States patents 4,937,299 and 5,317,036 (homogeneous polyethylenes); or other transition metal catalyst systems. Many of these catalyst systems are often referred to as Ziegler-Natta catalyst systems or Phillips catalyst systems. Catalyst systems, which use chromium or molybdenum oxides on silica-alumina supports, can be included here. Typical processes for preparing the polyethylenes are also described in the aforementioned patents. Typical in situ polyethylene blends and processes and catalyst systems for providing same are described in United States Patents 5,371,145 and 5,405,901. The various polyethylenes can include low density homopolymers of ethylene made by high pressure processes (HP-LDPEs), linear low density polyethylenes (LLDPEs), very low density polyethylenes (VLDPEs), medium density polyethylenes (MDPEs), and high density polyethylene (HDPE) having a density greater than 0.940 gram per cubic centimeter. The latter four polyethylenes are generally made by low pressure processes. A conventional high pressure process is described in Introduction to Polymer Chemistry, Stille, Wiley and Sons, New York, 1962, pages 149 to 151. The high pressure processes are typically free radical initiated polymerizations conducted in a tubular reactor or a stirred autoclave. In the stirred autoclave, the pressure is in the range of about 10,000 to 30,000 psi and the temperature is in the range of about 175 to about 250 degrees C, and in the tubular reactor, the pressure is in the range of about 25,000 to about 45,000 psi and the temperature is in the range of about 200 to about 350 degrees C.

[0012] The VLDPE can be a copolymer of ethylene and one or more alpha-olefins having 3 to 12 carbon atoms and preferably 3 to 8 carbon atoms. The density of the VLDPE can be in the range of 0.870 to 0.915 gram per cubic centimeter. It can be produced, for example, in the presence of (i) a catalyst containing chromium and titanium, (ii) a catalyst containing magnesium, titanium, a halogen, and an electron donor; or (iii) a catalyst containing vanadium, an electron donor, an alkyl aluminum halide modifier, and a halocarbon promoter. Catalysts and processes for making the VLDPE are described, respectively, in United States patents 4,101,445; 4,302,565; and 4,508,842. The melt index of the VLDPE can be in the range of about 0.1 to about 20 grams per 10 minutes and is preferably in the range of about 0.3 to about 5 grams per 10 minutes. The portion of the VLDPE attributed to the comonomer(s), other than ethylene, can be in the range of about 1 to about 49 percent by weight based on the weight of the copolymer and is preferably in the range of about 15 to about 40 percent by weight. A third comonomer can be included, e.g., another alpha-olefin or a diene such as ethylidene norbornene, butadiene, 1,4-hexadiene, or a dicyclopentadiene. Ethylene/propylene copolymers and ethylene/propylene/diene terpolymers are generally referred to as EPRs and the terpolymer is generally referred to as an EPDM. The third comonomer can be present in an amount of about 1 to 15 percent by weight based on the weight of the copolymer and is preferably present in an amount of about 1 to about 10 percent by weight. It is preferred that the copolymer contain two or three comonomers inclusive of ethylene.

[0013] The LLDPE can include the VLDPE and MDPE, which are also linear, but, generally, has a density in the range of 0.916 to 0.925 gram per cubic centimeter. It can be a copolymer of ethylene and one or more alpha-olefins having 3 to 12 carbon atoms, and preferably 3 to 8 carbon atoms. The melt index can be in the range of about 1 to about 20 grams per 10 minutes, and is preferably in the range of about 3 to about 8 grams per 10 minutes. The alpha-olefins can be the same as those mentioned above, and the catalysts and processes are also the same subject to variations necessary to obtain the desired densities and melt indices.

[0014] As noted, included in the definition of polyethylene are homopolymers of ethylene made by a conventional high pressure process. The homopolymer preferably has a density in the range of 0.910 to 0.930 gram per cubic centimeter. The homopolymer can also have a melt index in the range of about 1 to about 5 grams per 10 minutes, and preferably has a melt index in the range of about 0.75 to about 3 grams per 10 minutes. Melt index is determined under ASTM D-1238, Condition E. It is measured at 190 degrees C and 2160 grams.

[0015] Component (ii) is 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis(2-t-butyl-5-methylphenol); 2,2'-thiobis(6-t-butyl-4-methylphenol); or a mixture of said compounds. The amount of component (ii) that can be in the composition of the invention is in the range of about 0.3 to about 0.6 part by weight based on 100 parts by weight of component (i). It should be noted that this amount is the total amount of component (ii) regardless of whether it is a single compound or a mixture of two or more compounds.

[0016] Generally, the polyethylene glycol is defined by its molecular weight, which can be in the range of about 1000 to about 100,000, and is preferably in the range of about 5000 to about 35,000. The optimum molecular weight is 20,000 (prior to processing). It will be understood by those skilled in the art that processing the polyethylene glycol reduces its molecular weight by one third to one half. It will be further understood that the polyethylene glycol can be in the form of for example, a copolymer of ethylene glycol and ethylene or in any other form, compound or polymer, which provides the same functionality as polyethylene glycol. Polyethylene glycol is a polar compound, which can be represented by the formulas  $\text{HOCH}_2(\text{CH}_2\text{OCH}_2)_n\text{CH}_2\text{OH}$  or  $\text{HO}(\text{C}_2\text{H}_4\text{O})_n\text{H}$  wherein, for example, n can be 225 to 680. This translates into a molecular weight in the range of about 10,000 to about 35,000. The amount of polyethylene glycol that can be in the composition is a range of about 0.4 to about 1 part by weight based on 100 parts by weight of component (i).

[0017] It will be understood that, if one or more additional resins are introduced into the composition, the amounts of components (ii) and (iii) will be based on 100 parts by weight of the total resins in the composition. These resins can be various polyethylenes or polypropylenes, or other polymer additives commonly used in wire and cable.

[0018] Conventional additives, which can be introduced into the polyethylene formulation, are exemplified by antioxidants, coupling agents, ultraviolet absorbers or stabilizers, antistatic agents, pigments, dyes, nucleating agents, reinforcing fillers or polymer additives, slip agents, plasticizers, processing aids, lubricants, viscosity control agents, tackifiers, anti-blocking agents, surfactants, extender oils, metal deactivators, voltage stabilizers, flame retardant fillers and additives, crosslinking agents, boosters, and catalysts, and smoke suppressants. Fillers and additives can be added in amounts ranging from less than about 0.1 to more than about 200 parts by weight for each 100 parts by weight of the base resin, in this case, polyethylene.

[0019] Examples of antioxidants are: hindered phenols such as tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydrocinamate)methane, bis[(beta-(3,5-ditert-butyl-4-hydroxybenzyl)-methylcarboxyethyl)]sulphide, and thiodiethylene bis(3,5-di-tert-butyl-4-hydroxy)hydrocinamate; phosphites and phosphonites such as tris(2,4-di-tert-butylphenyl)phosphite and di-tert-butylphenyl-phosphonite; thio compounds such as dilaurylthiodipropionate, dimyristylthiodipropionate, and distearylthiodipropionate; various siloxanes; and various amines such as polymerized 2,2,4-trimethyl-1,2-dihydroquinoline and diphenylamines. Antioxidants can be used in amounts of about 0.1 to about 5 parts by weight per 100 parts by weight of polyethylene.

[0020] The resin, i.e., component (i), can be crosslinked by adding a crosslinking agent to the composition or by making the resin hydrolyzable, which is accomplished by adding hydrolyzable groups such as  $-\text{Si}(\text{OR})_3$  wherein R is a hydrocarbyl radical to the resin structure through grafting. It is preferred that the resin be crosslinked and that it be crosslinked with an organic peroxide.

[0021] The crosslinking of polymers with free radical initiators such as organic peroxides is well known. Generally, the organic peroxide is incorporated into the polymer by melt blending in a roll mill, a biaxial screw kneading extruder, or a Banbury™ or Brabender™ mixer at a temperature lower than the onset temperature for significant decomposition of the peroxide. Peroxides are judged for decomposition based on their half life temperatures as described in Plastic Additives Handbook, Gachter et al, 1985, pages 646 to 649. An alternative method for organic peroxide incorporation into a polymeric compound is to mix liquid peroxide and pellets of the polymer in a blending device, such as a Henschel™ mixer or a soaking device such as a simple drum tumbler, which are maintained at temperatures above the freeze point of the organic peroxide and below the decomposition temperature of the organic peroxide and the melt temperature of the polymer. Following the organic peroxide incorporation, the polymer/organic peroxide blend is then, for example, introduced into an extruder where it is extruded around an electrical conductor at a temperature lower than the decomposition temperature of the organic peroxide to form a cable. The cable is then exposed to higher temperatures at which the organic peroxide decomposes to provide free radicals, which crosslink the polymer.

[0022] Suitable crosslinking agents are organic peroxides such as dicumyl peroxide; 2,5-dimethyl-2,5-di(t-butylperoxy)hexane; t-butyl cumyl peroxide; and 2,5-dimethyl-2,5-di(t-butylperoxy)hexane-3. Dicumyl peroxide is preferred.

[0023] Hydrolyzable groups can be added, for example, by grafting an ethylenically unsaturated compound having one or more  $-\text{Si}(\text{OR})_3$  groups such as vinyltrimethoxysilane, vinyltriethoxysilane, and gamma-methacryloxypropyltrimethoxy-silane to the homopolymer in the presence of the aforementioned organic peroxides. The hydrolyzable resins are then crosslinked by moisture in the presence of a silanol condensation catalyst such as dibutyltin dilaurate, dioctyltin maleate, dibutyltin diacetate, stannous acetate, lead naphthenate, and zinc caprylate. Dibutyltin dilaurate is preferred.

[0024] Examples of hydrolyzable grafted copolymers are vinyltrimethoxy silane grafted ethylene homopolymer, .... vinyltriethoxy silane grafted ethylene homopolymer, and vinyltributoxy silane grafted ethylene homopolymer. ....

[0025] A cable using the composition of the invention can be prepared in various types of extruders, e.g., single or twin screw types. Compounding can be effected in the extruder or prior to extrusion in a conventional mixer such as a Brabender™ mixer or a Banbury™ mixer. A description of a conventional extruder can be found in United States patent 4,857,600. A typical extruder has a hopper at its upstream end and a die at its downstream end. The hopper feeds into a barrel, which contains a screw. At the downstream end, between the end of the screw and the die, is a screen pack and a breaker plate. The screw portion of the extruder is considered to be divided up into three sections, the feed section, the compression section, and the metering section, and two zones, the back heat zone and the front heat zone, the sections and zones running from upstream to downstream. In the alternative, there can be multiple heating zones (more than two) along the axis running from upstream to downstream. If it has more than one barrel, the barrels are connected in series. The length to diameter ratio of each barrel is in the range of about 15:1 to about 30:1. In wire coating, where the material is crosslinked with an organic peroxide after extrusion, the die of the crosshead feeds directly into a heating zone, and this zone can be maintained at a temperature in the range of about 130°C to about 260°C, and preferably in the range of about 170°C to about 220°C.

[0026] The advantages of the invention lie in the improved processability of the composition into a cable in terms of scorch resistance and reduction in sweat-out. In addition, heat aging and water tree growth resistance are as good or better than commercially available materials.

[0027] In certain polyethylene compositions, 4,4'-thiobis(2-methyl-6-t-butyl phenol) and 2,2'-thiobis(6-t-butyl-4-methylphenol) have been found to cause a color problem, which, in spite of their scorch inhibitor qualities can be commercially unacceptable. This problem is solved by adding hydroquinone or a substituted hydroquinone in a sufficient amount to inhibit color formation. Details can be found in a United States patent application filed on the same date as subject patent application by Michael J. Keogh for A Crosslinkable Polyolefin Composition (D-17874) bearing serial number \_\_\_\_\_.

[0028] The term "surrounded" as it applies to a substrate being surrounded by an insulating composition, jacketing material, or other cable layer is considered to include extruding around the substrate; coating the substrate; or wrapping around the substrate as is well known by those skilled in the art. The substrate can include, for example, a core including a conductor or a bundle of conductors, or various underlying cable layers as noted above.

[0029] All molecular weights mentioned in this specification are weight average molecular weights unless otherwise designated.

[0030] The patents, patent application, and publication mentioned in this specification are incorporated by reference herein.

[0031] The invention is illustrated by the following examples.

#### Examples 1 to 17

[0032] In the examples, the balance of each formulation, in percent by weight, is an ethylene homopolymer having a density of 0.92 gram per cubic centimeter and a melt index of 2 grams per 10 minutes, and is prepared by a high pressure process. All amounts are given in percent by weight based on the weight of the total formulation. PEG = polyethylene glycol having a molecular weight before processing of 20,000. Stabilizer A = 4,4'-thiobis-(2-tert-butyl-5-methylphenol). Stabilizer B = 4,4'-thiobis(2-methyl-6-t-butylphenol). Dicumyl peroxide is present in the formulations of examples 1 to 7 and 15 to 17 in an amount of 1.95 percent by weight. It is present in the formulation of example 14 in an amount of 1.75 percent by weight.

[0033] The resistance of insulating compositions to water treeing is determined by the method described in United States Patent 4,144,202. This measurement leads to a value for water tree resistance relative to a standard polyethylene insulating material. The term used for the value is "water tree growth rate" (WTGR). It is found that the WTGR is at a commercially acceptable level.

[0034] The homopolymer is compounded with PEG in a two roll mill operating at 24 revolutions per minute (rpm) on the front roll and 36 rpm on the back roll and a temperature of 125 to 130 degrees C on the two rolls for about 10 minutes. The procedure involves preheating the resin to 70 degrees C in an oven; fluxing the resin as quickly as possible on the two roll mill (about 3 to 4 minutes); adding PEG and 4,4'-thiobis-(2-tert-butyl-5-methylphenol) and fluxing for an additional 3 to 4 minutes; and then adding the peroxide and fluxing, peeling, and folding until well mixed. Sufficient dicumyl peroxide is introduced into each composition to provide an oscillating disk rheometer (5 degree arc at 360 degrees F) reading of 46 inch-pound. Each composition is then removed from the two roll mill as a crepe and diced and molded into one inch discs which are 0.25 inch thick in a press in two steps:

	initial step	final step
pressure (psi)	2,000	40,000
temperature (°C)	120	175
residence time (minutes)	9	15 to 20

[0035] Each plaque is tested for WTGR and the results compared with a control polyethylene composition, which exhibits 100 percent WTGR. Variables and results are set forth in Table I.

Table I

Example	1	2	3
PEG	0.4	0.6	0.8
Stabilizer A	0.4	0.4	0.4
WTGR(%)	40	25	16

[0036] The following formulations are prepared on a laboratory twin screw mixer using a mixing melt temperature of 200 degrees C followed by peroxide addition to effect crosslinking. The crosslinked material is then compression molded (using the condition described in WTGR sample preparation) into a laboratory plaque from which dog bone specimens as described in ASTM D-638 are prepared. The elongation property of the samples is tested without aging and after aging for 2 weeks in an air circulating oven at a temperature of 150 degrees C following ASTM D-638. The criterion for passing this test is to retain greater than 75 percent elongation properties after this aging protocol. As shown in Table II, the minimum level of 4,4'-thiobis-(2-tert-butyl-5-methyl-phenol) needed to meet this requirement is greater than 0.25 weight percent. The data demonstrates that 0.375 weight percent 4,4'-thiobis-(2-tert-butyl-5-methyl-phenol) meets this criterion with 0.4 and 0.6 weight percent PEG. See Table II for variables and results.

Table II

Ex.	4	5	6	7
PEG	0.4	0.4	0.6	0.6
Stabilizer A	0.25	0.375	0.25	0.375
Ret. Of Elong. (%)**	35	95	4	88

\*\* Retention of Elongation after aging in an air circulating oven at 150 degrees C for 2 weeks.

[0037] To measure the scorch (pre-cure during extrusion) resistance of the homopolymer of ethylene as prepared for examples 1 to 3, an instrument called Moving Die Rheometer (MDR) 2000, described in ASTM D-5289, and an Rubber Process Analyzer (RPA) 2000, manufactured by Alpha Technologies, are used here for illustration. The MDR Mh is the maximum torque which represents the total cure measured on a sample and is directly related to the total amount of active peroxide in the polymeric formulations. For accurate comparison of a material's scorch characteristics, the MDR Mh's should be comparable. Test conditions used for evaluating total cure by MDR are: 182 degrees C; 0.5 degree arc; 100 cycles per minute oscillation; 12 minutes test time. Torque is reported in units of pounds-inch (lbs-in). As seen in Table III, the total cure level of examples 8 and 9 to 13 are approximately comparable. The RPA was utilized to evaluate the material's resistance to scorch at actual extrusion conditions. This testing is conducted using conditions of 150 degrees C; 2.5 degree arc; 200 cycles per minute oscillation; 30 minutes test time. The resistance to scorch under these simulated extrusion conditions is gauged by the the RPA's Ts1, which is the time required for the torque to reach 1 lb-in above the minimum torque. Under these testing conditions, the higher the Ts1 value, the higher the resistance to scorch. As can be seen in Table III, the formulations with 0.3 percent or higher of stabilizer A or B result in significant improvement in scorch resistance by 18 percent or higher. The variables and results are set forth in Table III.

Table III

Ex.	8	9	10	11	12	13
PEG	0	0.6	0.4	0.6	0.4	0.6
Stabilizer A	0.18	0.18	0.30	0.375	0	0
Stabilizer B	0	0	0	0	0.30	0.375
DCP*	1.70	1.85	1.90	1.90	2.05	2.20
MDR Mh (lbs-in)	3.12	3.26	3.32	2.96	3.12	2.88
RPA Ts1 (min)	9.48	8.19	29.49	33.86	34.28	38.79

\* DCP = dicumyl peroxide

[0038] In order to test for additive sweat out (blooming to pellet surface), which can cause extrusion problems such as loss of output or diameter variation, a method involving washing 100 grams of pellets with 100 millimeters of methanol for 1 minute is used. The methanol is decanted after filtering through a 1 micron polypropylene filter, and is analyzed by High Pressure Liquid Chromatography (HPLC) for 4,4'-thiobis-(2-tert-butyl-5-methyl-phenol) concentration. As shown in the data, the presence of PEG helps to solubilize the 4,4'-thiobis-(2-tert-butyl-5-methyl-phenol) in the ethylene homopolymer thus reducing its sweat out by two orders of magnitude after conditioning at 50 degrees C for 8 weeks.

The variables and results are set forth in Table IV.

Table IV

Ex.	14	15	16	17
PEG	0	0.4	0.6	0.8
Stabilizer A	0.18	0.375	0.375	0.375
Sweat out (ppm) **	greater than 600	2	1	1

\*\* Concentration of Stabilizer A sweat out after 50 degrees C for 8 weeks in parts per million (ppm).

## Claims

### 1. A composition comprising:

- (i) a polyethylene, and, based on 100 parts by weight of component (i),
- (ii) 0.3 to 0.6 part by weight of 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis (2-t-butyl-5-methylphenol); 2,2'-thiobis (6-t-butyl-4-methylphenol); or a mixture of said compounds; and
- (iii) 0.4 to 1 part by weight of a polyethylene glycol having a molecular weight of 1000 to 100,000.

### 2. The composition defined in claim 1 wherein component (ii) is 4,4'-thiobis(2-methyl-6-t-butylphenol).

### 3. The composition defined in claim 1 wherein component (ii) is 4,4'-thiobis(2-t-butyl-5-methylphenol).

### 4. The composition defined in claim 1 wherein component (ii) is 2,2'-thiobis(6-t-butyl-4-methylphenol).

### 5. The composition defined in any one of claims 1 to 4 wherein the polyethylene glycol has a molecular weight of 5000 to 35,000.

### 6. A composition comprising:

- (i) a homopolymer of ethylene made by a high pressure process having a density of 0.910 to 0.930 gram per cubic centimeter and a melt index of 1 to 5 grams per 10 minutes, and, based on 100 parts by weight of component (i),
- (ii) 0.3 to 0.6 part by weight of 4,4'-thiobis(2-methyl-6-t-butylphenol); 4,4'-thiobis (2-t-butyl-5-methylphenol); 2,2'-thiobis (6-t-butyl-4-methylphenol); or a mixture of said compounds; and
- (iii) 0.4 to 1 part by weight of a polyethylene glycol having a molecular weight of 5000 to 35,000.

### 7. A cable comprising one or more electrical conductors or a core of electrical conductors, each conductor or core being surrounded by a layer of a composition as defined in any one of claims 1 to 6.



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# EUROPEAN SEARCH REPORT

Application Number  
EP 99 30 2852

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 735 545 A (UNION CARBIDE CHEM PLASTIC) 2 October 1996 (1996-10-02) * page 3, line 12 - line 19 * * example 2 *	1-7	H01B3/44 C08K5/13 H01B7/28
A	EP 0 057 604 A (NIPPON UNICAR CO LTD) 11 August 1982 (1982-08-11) ** examples **	1-7	
A	US 4 305 849 A (KAWASAKI YOUICHI ET AL) 15 December 1981 (1981-12-15) * table 1 *	1-7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01B C08K
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 4 August 1999	Examiner Paalman, R
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03/82 (P04C01)



**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 30 2852

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
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